Listing of Claims

1. (Currently Amended) A singulation engine for singulating a substrate into a plurality of smaller component parts, the singulation engine comprising:

a gang manifold assembly including a manifold configured to distribute a slurry to a plurality of nozzles, each of the nozzles being configured to discharge an individual jet stream in the form of a beam for cutting through the substrate at the same time; and

a chuck assembly configured to hold and support the substrate and the smaller component parts formed therefrom before, during and after the jet stream cuts through the substrate, the chuck assembly including one or more chucks, each chuck having a jet stream opening disposed therethrough for allowing the jet streams to pass after cutting through the substrate, each chuck including a vacuum platform and a vacuum manifold disposed underneath the vacuum platform, the vacuum platform being configured to receive the substrate and smaller component parts thereon, the vacuum platform including a plurality of vacuum openings, each of which is configured to apply a vacuum to the backside of the substrate and each of the smaller component parts formed therefrom, the vacuum manifold being configured to supply a vacuum to each of the openings so as to retain the substrate and each of the smaller component parts on the surface of the vacuum platform.

2. (Original) The singulation engine as recited in claim 1 wherein the slurry includes an abrasive and water.

3. (Original) The singulation engine as recited in claim 1 wherein the smaller component parts correspond to ball grid array packages, QFN packages or photonic devices.

4. (Original) The singulation engine as recited in claim 1 further including a pump and a holding tank, the holding tank being configured to store and receive the slurry, the pump being configured to pump the slurry from the holding tank to the gang manifold.

5. (Original) The singulation engine as recited in claim 1 wherein the manifold and nozzles are configured to move in a linear manner order to provide a linear cutting path.

6. (Currently Amended) The singulation engine as recited in claim [[1]] 10 wherein the chuck assembly includes one or more chucks, each chuck having a jet stream opening disposed therethrough for allowing the jet streams to pass after cutting through the substrate.

7. (Original) The singulation engine as recited in claim 6 wherein the chuck is an electrostatic chuck, a mechanical chuck or a vacuum chuck.

8. (Original) The singulation engine as recited in claim 6 wherein the chuck includes a vacuum platform and a vacuum manifold disposed underneath the vacuum platform, the vacuum platform being configured to receive the substrate and smaller component parts thereon, the vacuum platform including a plurality of vacuum openings, each of which is configured to apply a vacuum to the backside of the substrate and each of the smaller component parts formed therefrom, the vacuum manifold being configured to supply a vacuum to each of the openings so as to retain the substrate and each of the smaller component parts on the surface of the vacuum platform.

9. (Original) The singulation engine as recited in claim 1 wherein the chuck assembly includes a first chuck and a second chuck, the first chuck being configured to hold the substrate when the substrate is being cut by the jet streams in a first direction, the second chuck being configured to hold the substrate when the substrate is being cut by the jet streams in a second direction, the second direction being orthogonal to the first direction.

10. (Currently Amended) ~~The singulation engine as recited in claim 1 wherein~~ A singulation engine for singulating a substrate into a plurality of smaller component parts, the singulation engine comprising:

a gang manifold assembly including a manifold configured to distribute a slurry to a plurality of nozzles, each of the nozzles being configured to discharge an individual jet stream in the form of a beam for cutting through the substrate at the same time, the gang manifold including an inlet, a plurality of outlets, a slurry receiving channel and a plurality of slurry distribution channels, the plurality of slurry distribution channels being configured to receive the slurry from the inlet, and the plurality of slurry distribution channels being configured to distribute the slurry to the plurality of outlets, and wherein individual ones of the plurality of nozzles each are fluidly coupled to an individual outlet; and

a chuck assembly configured to hold and support the substrate and the smaller component parts formed therefrom before, during and after the jet stream cuts through the substrate.

11. (Currently Amended) A vacuum chuck assembly configured to hold an unsingulated substrate and the singulated substrate parts cut therefrom before, during and after jet stream singulation, the vacuum chuck assembly comprising:

a first chuck configured to hold the substrate during x axis cutting, the first chuck including a plurality of vacuum passageways and a plurality of cutting slots, the vacuum passageways being configured to provide suction to the substrate in order to hold the substrate before, during and after jet stream singulation, the cutting slots providing a space through which a jet stream passes when cutting in a first direction, the vacuum passageways including vacuum openings positioned in multiple rows and a vacuum channel disposed underneath each row of vacuum openings; and

a second chuck configured to hold the substrate during y axis cutting, the second chuck including a plurality of vacuum passageways and a plurality of cutting slots, the vacuum passageways being configured to provide suction to the substrate in order to hold the substrate before, during and after jet stream singulation, the cutting slots providing a space through which a jet stream passes when cutting in a second direction that is orthogonal to the first direction, the vacuum passageways including vacuum openings positioned in multiple rows and a vacuum channel disposed underneath each row of vacuum openings.

12. (Original) The vacuum chuck assembly as recited in claim 11 wherein the singulated substrate parts correspond to ball grid array packages, QFN packages or photonic devices.

13. (Currently Amended) ~~The vacuum chuck assembly as recited in claim 11~~ A vacuum chuck assembly configured to hold an unsingulated substrate and the singulated substrate parts cut therefrom before, during and after jet stream singulation, the vacuum chuck assembly comprising:

a first chuck configured to hold the substrate during x axis cutting, the first chuck including a plurality of vacuum passageways and a plurality of cutting slots, the vacuum passageways being configured to provide suction to the substrate in order to hold the substrate

before, during and after jet stream singulation, the cutting slots providing a space through which a jet stream passes when cutting in a first direction; and

a second chuck configured to hold the substrate during y axis cutting, the second chuck including a plurality of vacuum passageways and a plurality of cutting slots, the vacuum passageways being configured to provide suction to the substrate in order to hold the substrate before, during and after jet stream singulation, the cutting slots providing a space through which a jet stream passes when cutting in a second direction that is orthogonal to the first direction,

wherein each of the chucks includes a vacuum platform and a vacuum manifold disposed underneath the vacuum platform, the vacuum platform having a top surface on which the backside of the unsingulated substrate and the singulated substrate parts cut therefrom are placed before, during and after jet stream singulation, the vacuum platform including a plurality of vacuum openings each of which corresponds to one of the singulated substrate parts, the vacuum manifold including a plurality of vacuum channels that are fluidly coupled to the vacuum openings, the vacuum openings and the vacuum channels working together to form the vacuum passageways that distribute a suction force to the backside of the unsingulated substrate and the singulated substrate parts cut therefrom.

14. (Original) The vacuum chuck assembly as recited in claim 13 wherein the vacuum openings are disposed through the vacuum platform, and wherein the vacuum channels are recessed within the vacuum manifold.

15. (Original) The vacuum chuck assembly as recited in claim 13 wherein the cutting slots are formed by first slots disposed through the vacuum platform and second slots disposed through the vacuum manifold, the first and second slots being aligned with one another so as to form the cutting slots.

16. (Original) The vacuum chuck assembly as recited in claim 15 wherein the vacuum openings are positioned between the first slots, and wherein the vacuum channels are positioned underneath the vacuum openings between the second slots.

17. (Original) The vacuum chuck assembly as recited in claim 11 wherein the cutting slots of the first chuck are linearly positioned in the first direction, and wherein the cutting slots of the second chuck are linearly positioned in the second direction

18. Cancelled

19. (Currently Amended) ~~The vacuum chuck assembly as recited in claim 11 further including~~ A vacuum chuck assembly configured to hold an unsingulated substrate and the singulated substrate parts cut therefrom before, during and after jet stream singulation, the vacuum chuck assembly comprising:

a first chuck configured to hold the substrate during x axis cutting, the first chuck including a plurality of vacuum passageways and a plurality of cutting slots, the vacuum passageways being configured to provide suction to the substrate in order to hold the substrate before, during and after jet stream singulation, the cutting slots providing a space through which a jet stream passes when cutting in a first direction;

a second chuck configured to hold the substrate during y axis cutting, the second chuck including a plurality of vacuum passageways and a plurality of cutting slots, the vacuum passageways being configured to provide suction to the substrate in order to hold the substrate before, during and after jet stream singulation, the cutting slots providing a space through which a jet stream passes when cutting in a second direction that is orthogonal to the first direction; and

a base configured support the chucks in their desired position relative to each other, the base including a pair of voids, one of the voids being positioned underneath the first chuck, another of the voids being positioned underneath the second chuck, the voids coinciding with the cutting slots, the voids providing a space through which the jet stream passes after traveling through the cutting slots.

20. (Original) The vacuum chuck assembly as recited in claim 11wherein the vacuum platform is formed from a rubberized material.

21. (Original) The vacuum chuck assembly as recited in claim 11 wherein the rubberized material is Viton.

22. (Original) The vacuum chuck assembly as recited in claim 11 wherein the vacuum openings include a recessed portion at the top surface of the vacuum platform and a through hole disposed underneath the recessed portion

23. (Currently Amended) A method of singulating a substrate having a plurality of integrated circuits formed thereon, the method comprising:

producing one or more jet streams in the form of a beam, the configuration of the jet streams being sufficient to cut the substrate;

directing the jet streams over the surface of the substrate; and

selectively operating the jet streams so as to cut the substrate into the plurality of integrated circuits, selectively operating the jet stream including performing a first set of linear cuts in a first direction and performing a second set of linear cuts in a second direction, the first direction being orthogonal to the second direction,

wherein during the first set of linear cuts, the jet stream is caused to move back and forth in the first direction while being incremented in the second direction at the end of each traverse, and wherein during the second set of linear cuts, the jet stream is caused to move back and forth in the second direction.

24. (Original) The method as recited in claim 23 wherein selectively operating the jet stream includes performing a first set of linear cuts in a first direction.

25. (Original) The method as recited in claim 24 wherein during the first set of linear cuts, the jet stream is caused to move back and forth in the first direction while being incremented in a second direction at the end of each traverse, the second direction being orthogonal to the first direction.

26. (Currently Amended) ~~The method as recited in claim 25~~ A method of singulating a substrate having a plurality of integrated circuits formed thereon, the method comprising:

producing one or more jet streams in the form of a beam, the configuration of the jet streams being sufficient to cut the substrate;

directing the jet streams over the surface of the substrate; and

selectively operating the jet streams so as to cut the substrate into the plurality of integrated circuits, selectively operating the jet streams including performing a first set of linear cuts in a first direction,

wherein during the first set of linear cuts, the jet stream is caused to move back and forth in the first direction while being incremented in a second direction at the end of each traverse, the second direction being orthogonal to the first direction, and

wherein the jet stream is moved at a first speed in the first direction and at a second speed in the second direction, the first speed allowing the jet stream to cut through the substrate, the second speed being faster than the first speed in order to prevent cuts through the substrate.

27. (Original) The method as recited in claim 26 wherein the ratio between the second speed and the first speed is between about 40:1 to about 5:1.

28. Cancelled.

29. Cancelled.

30. (Currently Amended) The method as recited in claim [[29]] 23 wherein during the first set of linear cuts the jet stream is moved at a first speed in the first direction and at a second speed in the second direction, and during the second set of linear cuts the jet stream is moved at a first speed in the second direction and at a second speed in the first direction, the first speed allowing the jet stream to cut through the substrate, the second speed being faster than the first speed in order to prevent cuts through the substrate.

31. Cancelled.

32. Cancelled.

33. Cancelled.

34. (New) The singulation engine as recited in claim 1 wherein the vacuum openings are arranged in rows and columns and wherein the chuck includes a plurality of jet stream openings embodied as linear slots that are spatially separated and parallel to one another, each slot being separately positioned in the space found between the rows or columns of the vacuum openings.

35. (New) The singulation engine as recited in claim 34 wherein the jet stream openings are fully contained within the confines of the chuck, and further including a starter hole that provides a point for initiating a cutting sequence.

36. (New) The singulation engine as recited in claim 10 wherein each of the nozzles are coupled to the individual outlets via a coupling, and wherein a slurry distribution tube is coupled to the inlet via a coupling, the slurry distribution tube delivering slurry to the manifold from a slurry delivery assembly.

37. (New) The singulation engine as recited in claim 36 wherein the slurry delivery assembly includes a slurry containment vessel, a fluid source, and an abrasive source, the slurry containment vessel receiving fluid from the fluid source and abrasive from the abrasive source in order to generate the slurry, the slurry containment vessel being pressurized so that the slurry is delivered through the slurry distribution tube to the manifold.

38. (New) The singulation engine as recited in claim 37 wherein the abrasive source is a removable abrasive cartridge.

39. (New) The singulation engine as recited in claim 10 wherein each nozzle includes a nozzle tip attached to a nozzle body, the nozzle body including a tip receptacle for receiving the nozzle tip, the tip receptacle including a slope that matches the slope of the nozzle tip thus allowing the nozzle tip to be seated in the tip receptacle.

40. (New) The method as recited in claim 23 wherein the integrated circuits are lead-less integrated circuit packages.

41. (New) The method as recited in claim 40 wherein the lead-less integrated circuit packages are quad flat pack no lead (QFN) integrated circuit packages.

42. (New) The singulation engine as recited in claim 1 wherein the smaller components are integrated circuit packages.

43. (New) The singulation engine as recited in claim 42 wherein the integrated circuit packages are surface mount devices.

44. (New) The singulation engine as recited in claim 43 wherein the surface mount devices are selected from chip scale packages, ball grid arrays (BGA), flip chips, and lead-less packages.